

1 **Claims**

2

3 1. Apparatus for generating a mist comprising:
4 a conduit having a mixing chamber and an exit;
5 a working fluid inlet in fluid communication
6 with said conduit, the working fluid inlet adapted
7 to introduce a working fluid into the conduit; and
8 a transport nozzle in fluid communication with
9 the said conduit, the transport nozzle adapted to
10 introduce a transport fluid into the mixing chamber;
11 characterised in that the transport nozzle
12 includes a convergent-divergent portion therein such
13 as in use to provide for the generation of high
14 velocity flow of the transport fluid;
15 and wherein the transport nozzle and conduit
16 have a relative angular orientation such that in use
17 the working fluid is atomised and a dispersed
18 droplet flow regime of droplets is created in the
19 mixing chamber by the introduction of transport
20 fluid flow from the transport nozzle into working
21 fluid flow from the conduit and the subsequent
22 shearing of the working fluid by the transport
23 fluid, wherein the angular orientation of the
24 transport nozzle and conduit is such that the
25 shearing of the working fluid creates a dispersed
26 droplet flow regime in which a substantial portion
27 of the droplets have a size of less than 20µm.

28

29 2. The apparatus of claim 1, wherein the working
30 fluid droplets have a substantially uniform droplet
31 distribution having droplets with a size less than
32 20µm.

76

1

2 3. The apparatus of claim 1 or 2, wherein the
3 substantial portion of the droplets has a cumulative
4 distribution greater than 90%.

5

6 4. The apparatus of any preceding claim, wherein a
7 substantial portion of the droplets have a droplet
8 size less than 10 μ m

9

10 5. The apparatus of any preceding claim, wherein
11 the transport nozzle substantially circumscribes the
12 conduit.

13

14 6. The apparatus of any preceding claim, wherein
15 the mixing chamber includes a converging portion.

16

17 7. The apparatus of any of claims 1 to 5, wherein
18 the mixing chamber includes a diverging portion.

19

20 8. The apparatus of any preceding claim, wherein
21 the internal geometry of the transport nozzle has an
22 area ratio, namely exit area to throat area, in the
23 range 1.75 to 15, having an included α -angle
24 substantially equal to or less than 6 degrees for
25 supersonic flow, and substantially equal to or less
26 than 12 degrees for sub-sonic flow.

27

28 9. The apparatus of any preceding claim, wherein
29 the transport nozzle is oriented at an angle β of
30 between 0 to 30 degrees.

31

77

1 10. The apparatus of any preceding claim, wherein
2 the transport nozzle is shaped such that transport
3 fluid introduced into the mixing chamber through the
4 transport nozzle has a divergent or convergent flow
5 pattern.

6

7 11. The apparatus of claim 10, wherein the
8 transport nozzle has inner and outer surfaces each
9 being substantially frustoconical in shape.

10

11 12. The apparatus of any preceding claim, further
12 including a working nozzle in fluid communication
13 with the conduit for the introduction of working
14 fluid into the mixing chamber.

15

16 13. The apparatus of claim 12, wherein the working
17 nozzle is positioned nearer to the exit than the
18 transport nozzle.

19

20 14. The apparatus of claim 12 or 13 , wherein the
21 working nozzle is shaped such that working fluid
22 introduced into the mixing chamber through the
23 working nozzle has a convergent or divergent flow
24 pattern.

25

26 15. The apparatus of any of claims 12 to 14,
27 wherein the working nozzle has inner and outer
28 surfaces each being substantially frustoconical in
29 shape.

30

31 16. The apparatus of any preceding claim, further
32 including a second transport nozzle being adapted to

1 introduce further transport fluid or a second
2 transport fluid into the mixing chamber.
3

4 17. The apparatus of claim 16, wherein the second
5 transport nozzle is positioned nearer to the exit
6 than the transport nozzle.
7

8 18. The apparatus of claim 17, wherein the second
9 transport nozzle is positioned nearer to the exit
10 than the working nozzle, such that the working
11 nozzle is located intermediate the two transport
12 nozzles.
13

14 19. The apparatus of any preceding claim, wherein
15 the conduit includes a passage.
16

17 20. The apparatus of claim 19, wherein the inner
18 wall of the passage is adapted with a contoured
19 portion to induce turbulence of the working fluid
20 upstream of the transport nozzle.
21

22 21. The apparatus of any preceding claim, wherein
23 the mixing chamber includes an inlet for the
24 introduction of an inlet fluid.
25

26 22. The apparatus of any preceding claim, wherein
27 the mixing chamber is closed upstream of the
28 transport nozzle.
29

30 23. The apparatus of any preceding claim, further
31 including a supplementary nozzle arranged inside the
32 transport nozzle and adapted to introduce further

79

1 transport fluid or a second transport fluid into the
2 mixing chamber.

3

4 24. The apparatus of claim 23, wherein the
5 supplementary nozzle is arranged axially in the
6 mixing chamber.

7

8 25. The apparatus of claim 23 or 24, wherein the
9 supplementary nozzle extends forward of the
10 transport nozzle.

11

12 26. The apparatus of any of claims 23 to 25,
13 wherein the supplementary nozzle is shaped with a
14 convergent-divergent profile to provide supersonic
15 flow of the transport fluid which flows
16 therethrough.

17

18 27. The apparatus of any preceding claim, further
19 including control means adapted to control one or
20 more of droplet size, droplet distribution, spray
21 cone angle and projection distance.

22

23 28. The apparatus of any preceding claim, further
24 including control means to control one or more of
25 the flow rate, pressure, velocity, quality, and
26 temperature of the inlet and/or working and/or
27 transport fluids.

28

29 29. The apparatus of claim 27 or 28, wherein the
30 control means includes means to control the angular
31 orientation and internal geometry of the working
32 and/or transport and/or secondary nozzles.

80

1
2 30. The apparatus of any of claims 27 to 29,
3 wherein the control means includes means to control
4 the internal geometry of at least part of the mixing
5 chamber or exit to vary it between convergent and
6 divergent.

7
8 31. The apparatus of any preceding claim, wherein
9 the exit of the apparatus is provided with a cowl to
10 control the mist.

11
12 32. The apparatus of claim 31, wherein the cowl
13 comprises a plurality of separate sections arranged
14 radially, each section adapted to control and re-
15 direct a portion of the discharge of mist emerging
16 from the exit.

17
18 33. The apparatus of any preceding claim, wherein
19 the apparatus for generating a mist is located
20 within a further cowl.

21
22 34. The apparatus of any preceding claim, wherein
23 at least one of the transport, secondary or working
24 nozzles is adapted with a turbulator to enhance
25 turbulence.

26
27 35. A spray system comprising apparatus of any of
28 claims 1 to 34 and transport fluid in the form of
29 steam.

30
31 36. The spray system of claim 35, further including
32 working fluid in the form of water.

1

2 37. The spray system of claim 35 or 36, further
3 including a steam generator and water supply.

4

5 38. The spray system of claim 37, wherein the spray
6 system is portable.

7

8 39. A method of generating a mist comprising the
9 steps of:

10 introducing a flow of transport fluid into a
11 mixing chamber through a transport nozzle;

12 introducing a working fluid into the mixing
13 chamber through a conduit;

14 generating a high velocity flow of the
15 transport fluid by way of a convergent-divergent
16 portion within the transport nozzle;

17 orienting the transport nozzle and conduit such
18 that the high velocity transport fluid flow imparts
19 a shearing force on the working fluid flow; and

20 atomising the working fluid and creating a
21 dispersed droplet flow regime of droplets under the
22 shearing action of the working fluid on the
23 transport fluid, wherein the shearing action creates
24 a dispersed droplet flow regime in which a
25 substantial portion of the droplets have a size less
26 than 20µm.

27

28 40. The method of claim 39, wherein the apparatus
29 is an apparatus according to any of claims 1 to 38.

30

1 41. The method of claim 39 or 40, wherein the
2 stream of transport fluid introduced into the mixing
3 chamber is annular.

4

5 42. The method of any of claims 39 to 41, wherein
6 the working fluid is introduced into the mixing
7 chamber via an inlet of the mixing chamber of the
8 apparatus.

9

10 43. The method of any of claims 39 to 41, wherein
11 the working fluid is introduced into the mixing
12 chamber via a working nozzle in fluid communication
13 with the conduit of the apparatus.

14

15 44. The method of claim 43, wherein an inlet fluid
16 is introduced into the mixing chamber via an inlet
17 of the mixing chamber of the apparatus.

18

19 45. The method of any of claims 39 to 44, wherein
20 the method includes the step of introducing the
21 transport fluid into the mixing chamber in a
22 continuous or discontinuous or intermittent or
23 pulsed manner.

24

25 46. The method of any of claims 39 to 45, wherein
26 the method includes the step of introducing the
27 transport fluid into the mixing chamber as a
28 supersonic flow.

29

30 47. The method of any of claims 39 to 46, wherein
31 the method includes the step of introducing the

1 transport fluid into the mixing chamber as a sub-
2 sonic flow.

3

4 48. The method of any of claims 39 to 47, wherein
5 the method includes the step of introducing the
6 working fluid into the mixing chamber in a
7 continuous or discontinuous or intermittent or
8 pulsed manner.

9

10 49. The method of any of claims 39 to 48, wherein
11 the mist is controlled by modulating at least one of
12 the following parameters:

13 the flow rate, pressure, velocity, quality
14 and/or temperature of the transport fluid;

15 the flow rate, pressure, velocity, quality
16 and/or temperature of the working fluid;

17 the flow rate, pressure, velocity, quality
18 and/or temperature of the inlet fluid;

19 the angular orientation of the transport and/or
20 working and/or secondary nozzle(s) of the apparatus;

21 the internal geometry of the transport and/or
22 working and/or secondary nozzle(s) of the apparatus;
23 and

24 the internal geometry, length and/or cross
25 section of the mixing chamber.

26

27 50. The method of claim 49, wherein the mist is
28 controlled to have a substantial proportion of its
29 droplets having a size less than 20µm.

30

1 51. The method of claim 49, wherein the mist is
2 controlled to have a substantial proportion of its
3 droplets having a size less than 10µm.
4

5 52. The method of any of claims 39 to 51, including
6 the generation of condensation shocks and/or
7 momentum transfer to provide suction within the
8 apparatus.
9

10 53. The method of any of claims 39 to 52, including
11 inducing turbulence of the inlet fluid prior to it
12 being introduced into the mixing chamber.
13

14 54. The method of any of claims 39 to 53, including
15 inducing turbulence of the working fluid prior to it
16 being introduced into the mixing chamber.
17

18 55. The method of any of claims 39 to 54, including
19 inducing turbulence of the transport fluid prior to
20 it being introduced into the mixing chamber.
21

22 56. The method of any of claims 39 to 55, wherein
23 the transport fluid is steam or an air/steam
24 mixture.
25

26 57. The method of any of claims 39 to 56, wherein
27 the working fluid is water or a water-based liquid.
28

29 58. The method of any of claims 39 to 57, wherein
30 the mist is used for fire suppression.
31

85

- 1 59. The method of any of claims 39 to 58, wherein
- 2 the mist is used for decontamination.
- 3
- 4 60. The method of any of claims 36 to 59, wherein
- 5 the mist is used for gas scrubbing.